How second-growth Northern Hardwoods develop after thinning

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INTRODUCTION

IN THE NORTHERN HARDWOOD REGION, second-growth stands occupy thousands of acres. These stands are of all ages, in all conditions. They were brought about by fire, charcoal and fuelwood cuttings, land abandonment, or a combination of these causes.

Foresters disagree on how such stands should be managed. Some say even-aged management is just the thing. Others insist that uneven-aged management is better.

We have no ready answer to this question. But a study of one second-growth stand, showing how the stand developed after a thinning, provides some guides for choosing a suitable kind of management for such stands.

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THE STAND STUDIED

The study was begun in 1936, on a second-growth northern hardwood stand in the Bartlett Experimental Forest in New Hampshire. Its purpose was to measure the effects of a thinning, and to determine the productive capacity of such stands. Silvicultural factors bearing on continuous even-aged management were also considered.

The stand is on a north-facing slope at about 1,000 feet elevation. The area is nearly level. It is moist and well drained except for a small area along a brook. The site appears good for hardwoods as evidenced by moisture, depth of soil, and a good ground cover of Viburnum and Canadian yew.

The area was apparently clear-cut for fuelwood and then used as pasture. When abandoned, it reverted to second-growth hardwoods typical of the region. In 1936, the stand was 60 years old. Aspen, paper birch, red maple, and white ash were the main species. Yellow birch, sugar maple, and beech were present, but in much smaller quantities. In addition, there were a few scattered beech holdovers.

Table 1.--Basal area before thinning, by species

Species	Basal area	
	Square feet	Percent
Beech	4.07	3.3
Yellow birch	10.65	8.7
Sugar maple	10.76	8.8
Red maple	39.47	32.2
Paper birch	16.32	13.4
White ash	24.62	20.2
Aspen	14.51	11.9
Other	1.85	1.5
Total	122.25	100.0

A good part of the red maple was of sprout origin. Clumps had from two to six stems. This species tended to grow in nearly pure patches $\frac{1}{4}$ acre or more in extent. The aspen was overmature and dying. Most of the yellow birch had dropped below the general crown level, and was going to pieces--yellowing leaves, dead branches, and water sprouts. Otherwise the stand appeared healthy and vigorous. It was well stocked, with a good proportion of valuable species (table 1).

Second-growth stands are generally considered even-aged; and the structure of even-aged stands resembles the normal distribution. But this second-growth stand had the J-shaped structure associated with uneven-aged forests (fig. 1).

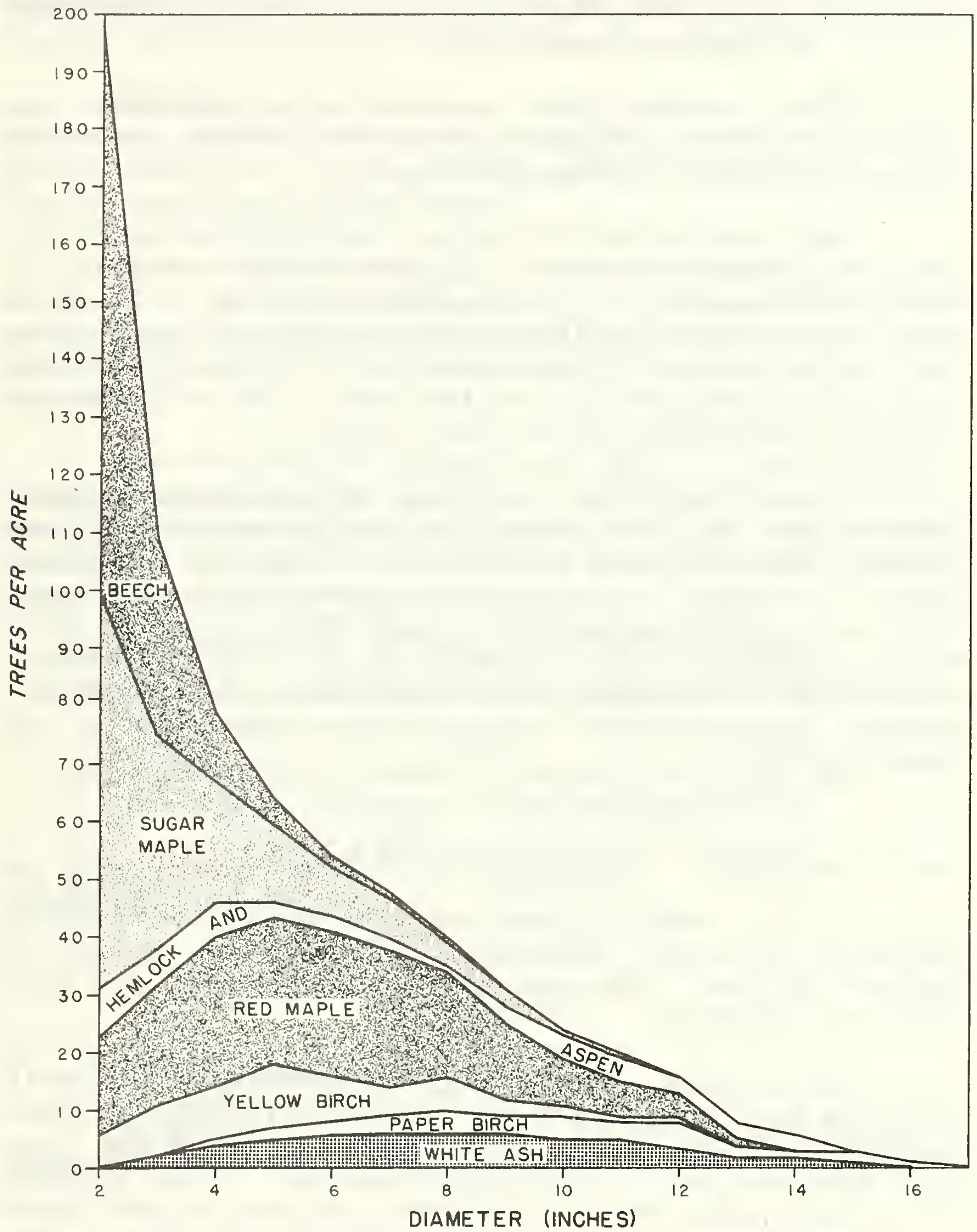

Figure 1.--Diameter distribution of the stand in 1936, by species.

This paradox can be explained by the growth habits of the species that comprise the stand. The more intolerant species (aspen, paper birch, white ash, yellow birch, and red maple) are especially suited for reforesting open areas. Once established, they either remain dominant or drop out. The very tolerant species (beech and sugar maple) grow slowly when the stand is established, but they can maintain themselves under intolerant dominants. They may even come in after the regeneration period.

These tolerant trees give the stand structure its J-shape. But the distribution of intermediate and intolerant species is typical of even-aged stands.

This stand structure has an important bearing on the form of management chosen. It lends itself naturally to uneven-aged management by the selection system. The many small stems are the growing stock from which successive harvest cuts will come. They will, in turn, be replaced by other small trees growing into the stand. The tolerant species will predominate in the future stand.

On the other hand, any form of even-aged management that employs only one harvest cut per generation will not benefit from these many small trees. They will contribute little or nothing to merchantable growth during the rotation, and when the harvest cut is made their potential value will be sacrificed. The tolerants may be cut at a financial loss or left to interfere with regeneration of the more intolerant species--which even-aged management usually is aimed to favor.

THE THINNING OPERATION

In this study, 44 contiguous $\frac{1}{4}$-acre plots were established in the stand described. The plots were marked in 1936 and thinned that winter. Four check plots were left uncut for comparison.

The thinning removed 20 to 30 percent of the basal area from each plot. All the holdover wolf trees and the aspen were removed. All other trees that would not live until the next cut (in 7-10 years) were cut. This included most of the yellow birch. Defective and poorly-formed trees of all species were removed so far as possible without opening the stand too much. In some cases the smaller stems in

red maple clumps were cut. Where possible, beech and red maple were cut to improve stand composition. The cut was a thinning to improve spacing, but emphasis was also on improvement of growing stock.

Tallies were made, before and after cutting, of all trees 1.6 inches d.b.h. or more. The trees were tallied by species and 1-inch diameter classes. New tallies were made in 1941 and 1951, and dead trees were also recorded.

Meanwhile, six plots were badly damaged by the 1938 hurricane. Others were lightly damaged. Consequently, the growth analysis for the period 1941-51 was based on 34 treated plots and 4 check plots.

Basal area (in trees 4.6 inches and larger) was used as a measure of volume and growth.[2] It is easily computed and suitable for management control. Because it is independent of height, it varies less between sites than cubic volume.

The stand-table method was used to get diameter growth. Basal-area growth is the difference in total basal area between the 1951 and 1941 inventories. This is "production." The dead-tree tally made it possible to separate growth into its components:

- Accretion--the growth on the initial trees.
- Mortality--the volume of trees that died during the period.
- Ingrowth--the volume of trees that grew past the minimum diameter of the measured stand.

Net growth is accretion minus mortality. Production is net growth plus ingrowth.

RESULTS

Diameter Increment

In general, diameter growth of the thinned stand reflects the differences among species in silvical character-

[2]To convert roughly to other units of measure, use these equivalents 1 square foot of basal area equals 20 cubic feet, or 1/5 standard cord.

istics and position in the stand structure (fig. 2 and table 2).

White ash and red maple 12 inches and larger made the best diameter growth. Growth dropped off toward the smaller sizes. The larger trees of the two species grew at about the same rate, but among the smaller trees ash growth was slower.

Table 2.--Annual diameter growth, by species, 1941-51

Species	Average diameter breast high in 1941	Average annual growth
	Inches	Inches
Red maple	7.79	0.129
White ash	9.41	.124
Paper birch	10.88	.102
Yellow birch	7.24	.107
Beech	6.06	.161
Sugar maple	6.86	.148
Average	8.07	0.132

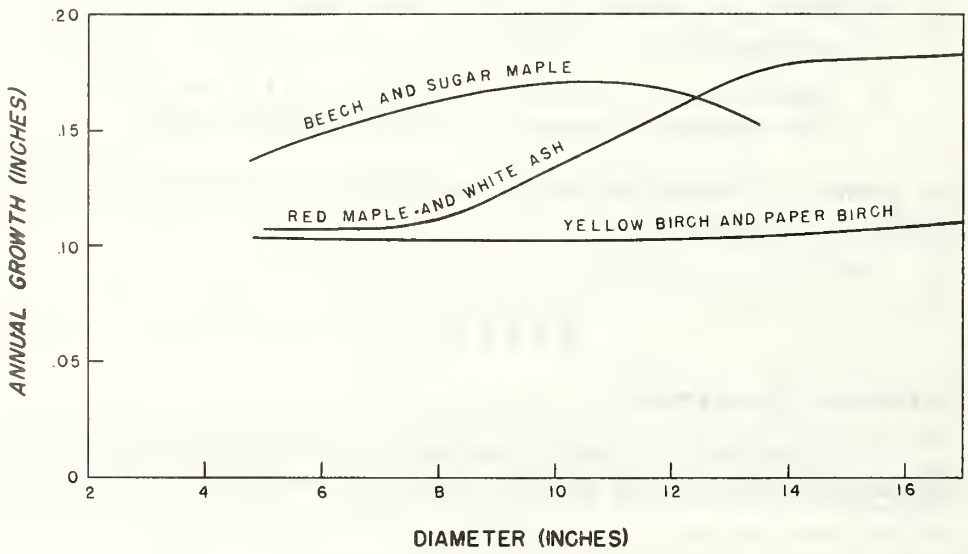

Figure 2.--Annual diameter growth of the thinned stand.

All birch grew very slowly. Paper birch on this site reached maturity at about 70 years and growth has slowed down. Yellow birch--normally a slow-growing species--has fallen behind the rest of the stand so that it can no longer get the full sunlight it needs for vigorous growth.

Beech and sugar maple grew well in the smaller size classes with a moderate amount of light. However, diameter growth culminated at a relatively small size. The best growth was at 11 inches; after that size, growth fell off.

Basal-Area Growth

The distribution of trees by species and size class affects the basal-area growth rate of the stand the same way species and size affect the growth rate of a tree (table 3). On the average acre of the thinned stand:

Table 3.--Basal-area growth in square feet per acre, by species, 1941-51

Item	Beech	Yellow birch	Sugar maple	Red maple	Paper birch	White ash	Other	All species
Trees 4.6 inches d.b.h. and larger:								
1951 inventory	6.46	4.08	17.92	32.24	12.30	30.07	2.74	105.81
1941 inventory	2.54	3.23	10.93	24.83	11.55	25.05	1.68	79.81
Production	3.92	.85	6.99	7.41	.75	5.02	1.06	26.00
Ingrowth	2.61	.24	2.71	1.39	.03	.16	.76	7.90
Net growth	1.31	.61	4.28	6.02	.72	4.86	.30	18.10
Mortality	.06	.23	.55	1.84	1.30	1.67	.27	5.92
Accretion	1.37	.84	4.83	7.86	2.02	6.53	.57	24.02
Trees 10.6 inches d.b.h. and larger:								
1951 inventory	1.06	0.58	4.65	14.69	10.60	21.72	0.42	53.72
1941 inventory	.68	.30	1.86	6.83	9.22	14.29	.36	33.54
Production	.38	.28	2.79	7.86	1.38	7.43	.06	20.18
Ingrowth	.23	.23	2.27	6.25	.70	5.15	.09	14.92
Net growth	.15	.05	.52	1.61	.68	2.28	-.03	5.26
Mortality	--	--	--	.34	.87	1.16	.08	2.45
Accretion	.15	.05	.52	1.95	1.55	3.44	.05	7.71

- In 10 years the thinned stand produced 26.00 square feet of basal area. Red maple and white ash produced almost half of this volume, sugar maple 27 percent.
- Loss through mortality was 5.92 square feet. This reduced the possible yield for the period by almost one-fifth. Red maple, paper birch, and white ash made up four-fifths of this loss.

- Accretion on the initial trees was 24.02 square feet. Red maple accounted for 60 percent of this, sugar maple for 20 percent.
- Ingrowth produced 7.90 square feet of new basal area. This was almost one-third of the stand's production. More than two-thirds of the ingrowth was beech and sugar maple.

Sugar maple and beech basal areas are increasing at a faster rate than red maple, white ash, and paper birch. The intolerant species are producing half the basal-area growth, but beech and sugar maple are doing almost as well. Mortality is heavy in the intolerants, light in the tolerants. Ingrowth of beech and sugar maple is strong and has added almost 40 percent to the basal area of these species since the beginning of the period.

Growth Of Sawlog-Size Trees

The usable volume of the stand is concentrated in trees 11 inches d.b.h. and larger. In 1951 these larger trees accounted for more than half the basal area (10 years earlier it was only 42 percent).

Although sawlog trees accounted for three-fourths of the total production, more than two-thirds of it was ingrowth from the poletimber class. Actually only 32 percent of the total accretion was laid on trees 11 inches d.b.h. and larger.

Sawtimber mortality was in proportion to its volume in the stand. Almost half of this loss was white ash; none of the beech, sugar maple, or yellow birch died.

At 75 years the sawtimber stand is still mainly red maple, paper birch, and white ash. There is little beech or sugar maple.

Evaluation Of The Thinning

The average annual diameter growth is about 0.045 inch greater on the thinned area (fig. 3). This is roughly 50 percent more than the check-plot average. The increase is due to (1) removal of poor, slow-growing, and dying trees; and (2) additional growing space made for the residual trees.

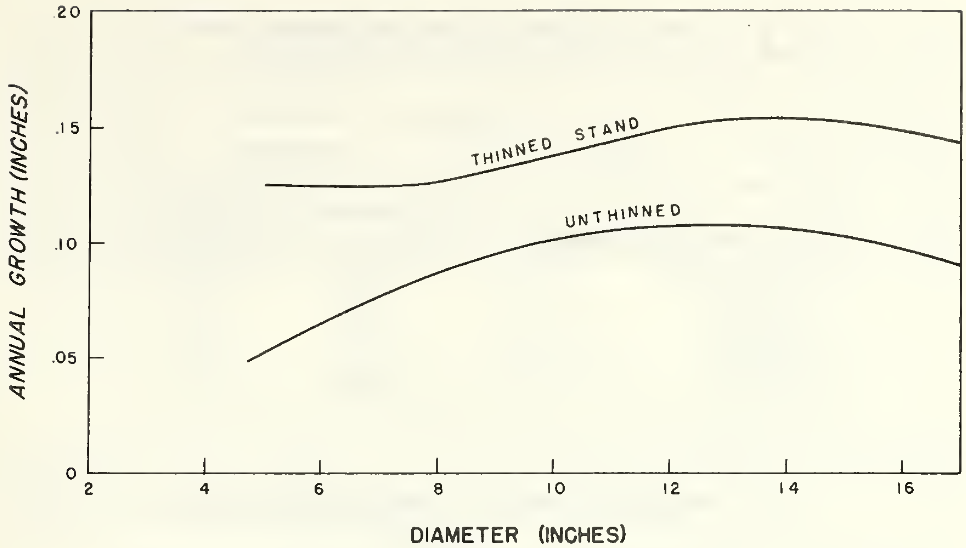

Figure 3.--Annual diameter growth of both thinned and unthinned stands, all species.

We do not have enough data to appraise the relative importance of these causes. General observation of the stand before thinning indicated that it was vigorous and had fairly good crown differentiation. Therefore, increased growing space probably stimulated the growth of the smaller trees. Removal of slow-growing trees was most important in increasing the growth rate of the large dominant trees.

Nearly all the aspen died on the check plots, and birch is dropping out of both stands. All species grew more slowly on the check plots except white ash (which was the same).

Accretion was 11 percent greater on the thinned plots, and it was laid on fewer and better trees. This represented an annual rate of 3.0 percent for the thinned plots, and only 1.7 percent for the check plots. On the thinned stand, mortality was one-third (one-half if aspen is excluded), ingrowth twice, and production four times that on the check stand. Average annual production was 3.3 percent for the treated stand and 0.5 percent for the checkplots (table 4).

The effect of the single thinning on yields is clearly seen by comparing mean annual increment and current annual increment of the two stands (table 5). For the check

Table 4.--Basal-area growth of thinned and unthinned stands, in square feet per acre 1941-51

Item	Thinned	Unthinned	
	All species	All species	All species except aspen
1951 inventory	105.81	132.77	129.92
1941 inventory	79.81	125.95	117.82
Production	26.00	6.82	12.10
Ingrowth	7.90	3.90	3.90
Net growth	18.10	2.92	8.20
Mortality	5.92	18.50	12.72
Accretion	24.02	21.42	20.92

Table 5.--Basal-area increment of thinned and unthinned stands, by periods

Date	Age of stand	Thinned		Unthinned	
		Mean annual increment	Current annual increment	Mean annual increment	Current annual increment
	Years	Square feet per acre per year			
1936	60	2.04	--	2.09	--
1941	65	2.05	--	1.94	--
1946	70	2.09	2.60	1.85	0.68
1951	75	2.13	--	1.76	--

stand the mean annual increment is falling each year and the current annual increment was well below it in 1946. The treated stand shows a continued increase in mean annual increment, and current annual increment is still above it. Yield is dropping on the check stand, but on the treated stand it is still rising.

In brief, the thinning benefited the stand by:

- Turning much mortality into yield.
- Increasing accretion a little and putting it on better trees.
- Increasing current and mean annual increment.
- Increasing ingrowth--which may or may not be a benefit depending on the aims of management.

Thinning hastened the conversion of the stand to a climax type. The structure is now more nearly J-shaped than it was before treatment. In the 15 years since cutting, the proportion of beech and sugar maple has increased more in the treated stand than in the check stand. Before cutting the thinned stand, 12 percent of the basal area was in tolerant species; now they make up 23 percent. On the check plots the increase was from 20 percent to 25 percent for the same period.

CONCLUSIONS

In this study of a second-growth stand of northern hardwoods, two points related to the management of such stands have been developed.

First, at 60 years of age and without management, this subclimax stand was changing to the climax type with an uneven-aged structure.

Second, a single improvement thinning raised the growth and yield of the stand but also hastened the change to a climax stand.

Both points emphasize that management of intolerant but desirable species is difficult. Under even-aged management, the development of a tolerant understory contributes little to the yield of the stand. Furthermore, it interferes with regeneration of intolerant species for the next rotation. The different ages of maturity among the intolerant species may call for separate rotation ages for each. Under uneven-aged management only a small part of the stand would be intolerant species.

On a good site, uneven-aged management is natural and easy. On the other hand, if the greatest amounts of paper birch, white ash, and yellow birch are required, some form of even-aged management must be practiced. If the decision is made early in the life of the stand, intermediate cuts or thinnings can shape the stand to meet the goal.

In even-aged management, the canopy should be opened very little, by making light thinnings from below. In this way weak and dying trees can be salvaged, average stand diameter can be raised, and satisfactory growth can be maintained. Dominant trees of poor quality or low value (such

as aspen) can be cut early to keep crown openings small. By maintaining a reasonably closed canopy, the stand can be kept in the best condition for the harvest or reproduction cut.

Heavier cuttings can be used to convert to an all-aged stand, and they can be made through all the crown classes. The J-shaped structure will be strengthened, and stand composition will improve. As the intolerant species mature and are cut, tolerant species will replace them. A smooth transition from even- to uneven-aged stands--and uninterrupted yields--will result.

Whatever the choice, thinnings should be frequent, and they should be started as early as practical. Thinnings should be started at 40 years of age (or earlier) and repeated every 10 years (or oftener).

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